STATE ENGINEERING EXPERIMENT STATION

The Research Engineer

GEORGIA INSTITUTE OF TECHNOLOGY

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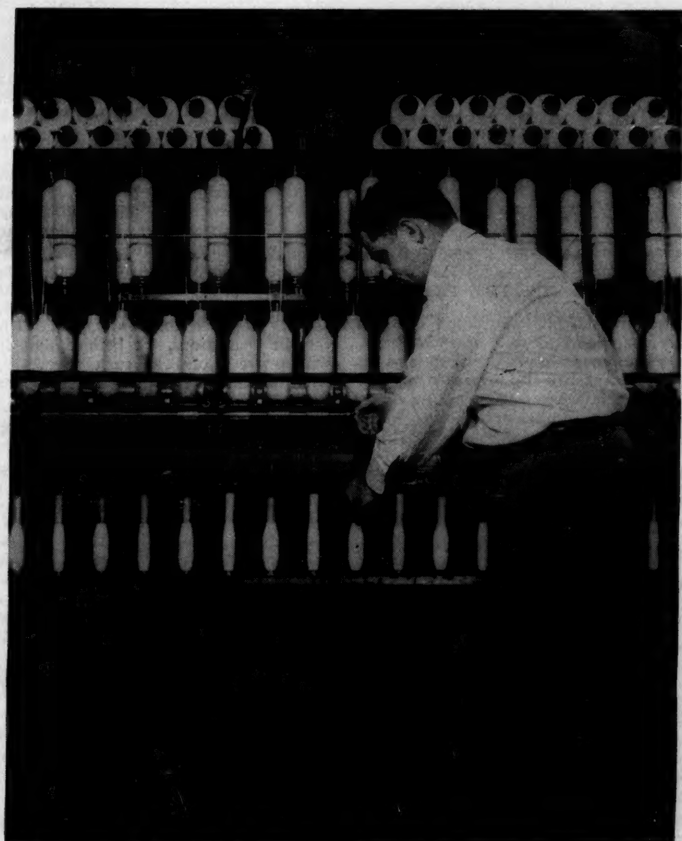

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BUILDING FOR THE FUTURE

The start of a new year is a good time for companies, as well as individuals, to examine past performance and to chart a course for the future. Many will conclude, however well they have done, that they could have done better. Some, through research, will actively seek means to do better, and it is their stock that we would like to own. For next year, the following year or a decade from now they will be the companies whose annual reports show growth in assets and expanded income from new and better products.

We have recently seen a tabulation of the average numbers of United States patents issued annually during 1949 through 1951 to 193 domestic companies which comprise a representative cross section of American industry. The *Technical Survey* published the list as an index of the research activity of these companies, and, with certain limitations, we believe that it will prove useful as such. However, what impresses us most was the fact

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No one will deny that American production, science and technology are our ace in the hole in defending ourselves and the free world against the numerically superior forces that threaten us. The advance of both science and technology depends almost exclusively upon the supply of technically trained manpower, and the scarcity of such men is rapidly becoming the outstanding bottleneck to production also. In production we cannot ignore either the contributions of Labor or of Capital, for both are undeniably indispensable. To reward one unduly, at the expense of the other, is obviously unfair, since Labor provides the operators and Capital supplies the funds for the machines which make possible our tremendous production. Yet we have ignored a third, relatively small group which is fully as important to abundant production and which is morally as fully, or more fully, entitled to a fair share of the profits therefrom. I mean the engineers who conceive, design and build the complex machines of modern industry. Too often their salaries are less than the wages of the welders and bricklayers who give their creations physical form or of the men who turn the controls on the finished machines.

If we are to improve the desperate technical manpower situation, we must make science and technology financially rewarding as well as intellectually stimulating. Capable, ambitious young men must come to view engineering and the sciences as a profitable career rather than a noble sacrifice. Then, and only then, may we expect a greater influx of top quality youth into training for the professions which hold most promise of keeping America free and prosperous.

BLAKE R. VAN LEER

President, Georgia Institute of Technology

PRODUCT RESEARCH AS AN AID TO SOUTHERN INDUSTRY

By FRED W. COX, JR.*

The Georgia Chapter of the Society for the Advancement of Management recently asked Dr. Cox to speak before its members on the general subject of product research and, particularly, on its applications to the problems of Southern industry. With minor changes and slight condensation, the following article reproduces Dr. Cox's talk.

Fred W. Cox, Jr.

Product research, or industrial research, as I have chosen to define the topic for tonight, is relatively a newcomer to the industrial development of the world. Prior to about 1900 our new products, new machinery and new manufacturing processes came about by a slow process of evolution. Ingenious people applied meager knowledge of natural phenomena to invent such things as the wheel, the sail, the metallurgy of copper and later of iron, the steam-powered devices, etc. Other people made small improvements, to which were added more small improvements so that over a period of years there evolved a machine or a process which did a fairly good job of producing the manufactured articles of commerce then available. Since about 1900, we have not only learned to apply our knowledge of natural processes in an intensive manner to produce what are sometimes called "The Miracles of Modern Science," but we also have sought to intensify our search for greater knowledge of natural phenomena. As a by-product, we have been able to bring about many processes, giving useful products which, so far as is known, have never occurred in nature. This has resulted in what we might call the "Scientific Revolution." As a result I would estimate that better than 50 per cent of our manufactured products, which incidentally make possible our present high "standard of living," are now being produced by processes or on machinery unknown prior to 1900.

For instance, let's look at the giant synthetic fiber industry; rayon, nylon, Dacron, Saran, Vinyon, and many others. Also, look at the petroleum industry, the automobile industry, the aircraft industry, the antibiotic drug industry and, even more spectacular, the atomic energy industry—these are all products of our intensive research, both fundamental and applied.

However, these developments are obvious. Anyone can pick out the spectacular, but not every industry can afford a multimillion dollar development like nylon, and none, a multibillion dollar development like atomic power. There are not many du Ponts or U. S. Governments with capital like that to spend. While it is true that many of the larger units of established industries, such as du Pont, Monsanto Chemical, Eastman Kodak, the Aluminum Company of America and Goodyear Tire and Rubber Company, have built large plants and, in some cases, research laboratories in the Southeast, the great majority of southern industries may be classified as Small Industry. In this category, I would also classify most of our textile mills, although some of them may debate the point with me.

These smaller industries have problems whose solutions are just as vital to their existence as are the problems of Big Industry. Although less spectacular than some of the research accomplishments enumerated above, they are equally stimulating to management and to research workers who may apply their talents to solving them. Realizing the need for scientific research by companies which have no formal research organizations of their own, Dr. Robert Kennedy Duncan conceived the idea of an independent research institute supplying technical personnel and facilities for the solution of industrial problems on a contract or fel-

*Assistant Director.

lowship basis. Enlisting the financial aid of the Mellon brothers, he developed the well-known Mellon Institute which has literally been the cradle of one of our present big chemical organizations, the giant Carbide and Carbon Chemical Company.

Following the general philosophy of Duncan, if not his method of operation, other such institutes have sprung up as independent organizations or organizations closely allied with educational institutions; e.g., Battelle Memorial Institute, Armour Research Foundation, the Institute of Paper Chemistry, the Purdue Research Foundation, the Ohio State Research Foundation and, in the South, the Georgia Tech Engineering Experiment Station, its affiliate, Georgia Tech Research Institute, and the Southern Research Institute.

These organizations not only include on their staffs scientists who are interested in the fundamental or basic laws of nature, but they also maintain large groups of technical and engineering personnel who are highly capable of solving the basic engineering and applied research problems of Industry. The pure scientist is concerned with discovering new principles or developing new processes; the engineer, or applied scientist, is primarily concerned with applying existing knowledge to the solution of industrial problems. This latter may encompass the design of new processes, new machines and new manufacturing methods or the perfection of existing equipment or processes. In general, Southern industry, like all industry, needs both; but by far the greater immediate need is for engineering or applied research and, in many cases, the need is simply for good, sound technical advice.

A typical example of this basic conflict between the needs of a particular industry for basic research and those for applied research is the case history of a research program instigated by a medium-sized Southern company in one of the independent research institutes. This company, a producer of raw material for one of our largest heavy industries, had been content for a long time with the simple production of the raw material and sale of a few by-products to a processor in the North. A shift toward a more progressive management, along with the energetic help of a few far-sighted production men, brought realization that these by-products were the basis of a chemical business that might prove profitable for the company. Since profits are highest in the manufacture of final products usable by the general public, they decided upon what chemical engineers call a "vertical operation"; that is, they decided to go into the business of manufacturing chemical products which would utilize as many of their own raw materials and secondary products as possible. First, they began using one by-product as a blending agent for high-octane gasoline. Then one of their operations engineers had the idea of utilizing another by-product to make resins for a protective coating. Here they ran into difficulties with an inferior product and had to call on a research laboratory for technical assistance. In a relatively short time and with a modest expenditure of money, the problems were solved and the company's coatings business prospered to the extent that a new plant was built. This outcome was the result not of discovery of new principles or processes but simply of the application of existing knowledge to solution of the company's problem combined with the use of common sense in adapting the solution to the company's know-how, equipment and over-all ability.

The management was so pleased with this work that it decided to expand the research program and investigate application of the company's other crude products to its paint business. At this point the fundamental research advocates of the research institute's staff decided that now was the time to "promote" a basic research project. The management, flush with the success of the applied research project and eager to get on with its general program of expansion into the chemical business, was easily sold on the idea to set up a second research project. Instead of realizing that the company's basic needs were for the development of products which could be produced almost immediately, which required a minimum amount

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A RESILIENT FLOORING AND SURFACING COMPOSITION

By W. R. TOOKE, JR.,* *and* JOHN C. LANE**

A new composition for trowel application over rough concrete floors and other surfaces where a water-resistant, long wearing, permanently attractive, moderate-cost covering is desired has been developed by the Station's Coating Laboratory. The following article describes the new product and some of the study that went into its development.

Full-scale experimental installations of a Georgia Tech-developed flooring and surfacing composition indicate that it has definite commercial potentialities. Applied over concrete, it provides a long wearing surface which is resistant to water, impact and abrasion. Its flexibility and its ability to bond to metal, glass, plaster, plaster board, wood and all types of masonry permit applications to be made over large areas of various substrates without use of anchoring clips or expansion joints. These properties naturally suggest a number of uses, only a few of which have yet been explored.

**Research Assistant.*
***Research Professor and Head, Technical Information Service.*

The original goal of the research leading to development of this composition was to discover a material which could be trowel-applied over unfinished concrete surfaces to produce an integral, good quality flooring. Such a material was desired by the project sponsor, Mr. O. I. Freeman, a professional engineer of Atlanta, for use with a new system of concrete construction which he had devised. However, the characteristics of the composition, as developed, suggest quite widespread applications in the industrial field, its uses being by no means limited to interiors. It appears to offer promise both as a moderately resilient surfacing material and as a patching composition for all types

Figure 1. The floor of this kitchen consists of the new composition applied over expanded metal lath nailed to the original wooden flooring. The plaster wall surfaces are also covered with the composition to which a coating of oil-base paint has been applied.

of concrete surfaces. Besides interior floors, its potential uses include walls and stairways, exterior platforms, walks, concrete aprons, buildings, bridges and other structures requiring protection or patching. The composition's good adhesion to metal suggests application to ship decks and other steel floors requiring both protection and durable non-skid surfaces.

The composition, basically off-white in shade, can be produced in a variety of pleasing colors by incorporation of certain types of aggregates. Properly compounded, it can be sanded down as easily as hardwood floors to produce attractive terrazzo effects. While many of its uses in commercial buildings, apartment buildings and homes would parallel its industrial applications, decorative treatments could be emphasized. The terrazzo-type floorings should prove particularly popular in view of the potential savings obtainable from use of simplified application techniques. Much-needed recreation areas might be provided in crowded urban centers by using the new material as a waterproofing coating over concrete roofs.

Based on limited tests, application over wooden floors, platforms, etc., appears practical so long as the supporting structure is capable of supporting the additional load. To date, the test installations have all been made over light expanded metal lath attached to the wood prior to application of the material. Either with or without the metal lath base, depending upon the particular case, the composition apparently offers an economical method of surfacing wooden floors to improve both their attractiveness and their durability.

Application of the terrazzo-type formulation to transite panels, followed by sanding and polishing, produces a kind of artificial stone. Tests indicate that such precast products would be inexpensive and attractive for use as store fronts, as window sills, as floor molding, on hearths and for numerous types of decorative trim.

Slight modifications of the composition result in a mortar suitable for setting marble, tile and similar products. Other modifications can be used as premium-quality putty, pointing material and spackle.

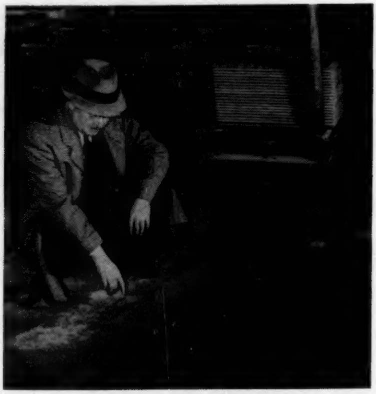

Figure 2. After eight months of abuse, this composition-protected aisle intersection in a woodworking plant shows no sign of the wear exhibited by the unprotected concrete floor.

DEVELOPMENT WORK

In the fall of 1950, Mr. Freeman asked the Engineering Experiment Station to undertake research directed toward development of a flooring composition which would be moderate in cost, simple to manufacture, easy to apply by troweling methods and rapidly enough setting to bear traffic within 24 hours. For use with his method of construction, the composition also had to adhere firmly to concrete and to withstand wear. Attractive appearance with minimum maintenance and resiliency under foot were among the desired characteristics. In order to make application as simple as possible while insuring storage stability, it was desired to supply the formulation in two parts, one a liquid and the other a dry mix.

While the proprietary rights of the sponsor preclude detailed description of the product and the research leading to its development, some generalized discussion may be presented. First, various binder systems were studied to find one which, in addition to possessing the set strength and other necessary attributes, would set from a liquid or plastic state to a solid state

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LOW-TEMPERATURE RESEARCH IN EUROPE

By W. T. ZIEGLER*

Dr. Ziegler, head of the Station's low-temperature laboratory, recently combined attendance at two international scientific conferences in England with appearance on the program of one and an inspection tour of outstanding low-temperature laboratories both in Great Britain and on the Continent. In the following article he presents some of his impressions of the over-all experience.

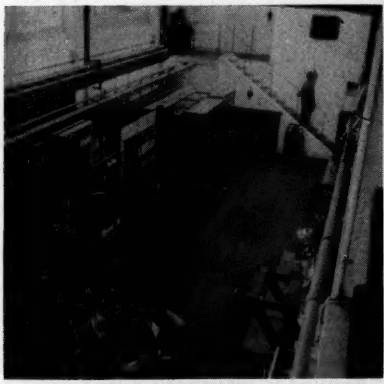
During the past summer I had the good fortune to present a paper at the International Conference on Low-Temperature Physics which was held at Oxford University, England, August 22-28, 1951. In addition, I attended part of the sessions of the 8th International Congress of Refrigeration, held in London August 29-September 5. Following these conferences, I visited a number of laboratories engaged in low-temperature research in France, Germany, Holland and Belgium. In the course of this trip I also had the opportunity to visit relatives in Germany and to make a brief sight-seeing trip to Switzerland and Austria. It is with the hope that some of the impressions gathered on this trip will be of general interest that I set them down.

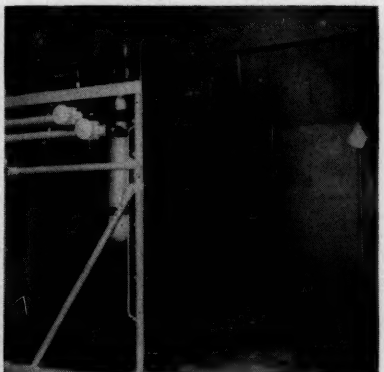
I wish to express my appreciation for the assistance of the Office of Naval Research (ONR) which made possible my attendance at the conferences in England and to the Georgia Tech Alumni Foundation for a generous grant that made possible my visit to the low-temperature laboratories on the Continent.

**Research Professor of Chemical Engineering.*

THE TRIP TO ENGLAND

The trip by air to England was an interesting one, doubly so because it was my first trip to Europe. I left Atlanta by train on Sunday evening, August 12. On Monday afternoon I joined two members of the physics branch of ONR and two scientists from the National Bureau of Standards at the Naval Air Station at Anacostia, District of Columbia. We flew to Patuxent River, Maryland, where we spent the night. The next morning we boarded a DC-4 plane operated by the Fleet Logistic Air Wing. Our flight took us to Pt. Lyautey, French Morocco, North Africa, where we arrived on the afternoon of August 15, having





Figures 1 and 2. Dr. Ziegler went through several scientific laboratories during his trip. Among them were the Mond Laboratory at Cambridge (left) and Oxford's low-temperature laboratory where he inspected its hydrogen liquefier (right).

stopped en route at Quonset Point (Rhode Island), Argentia (Newfoundland), and Lagens (the Azores). Late in the afternoon a number of us visited the small nearby town of Lyautey with its native Arab quarters. Here I had my first experience with the complexities of foreign currency.

The next morning we continued our flight to London arriving at Bovington airport about 2:00 p.m. The entire flight had been made in good weather which added considerably to our enjoyment. After passing through British customs, we were taken by bus to the London Branch Office of ONR where we were welcomed in a most cordial manner and provided with hotel accommodations.

LONDON AND CAMBRIDGE

The time from Thursday through Monday, August 20, was spent in learning something of London. So many things of which I had read were to be seen and felt—the people, the customs, the historic buildings, the war damage. Each made its imprint on the mind and spirit of the visitor.

On Tuesday morning, August 21, we, together with other visitors who were to attend the Oxford conference, went by train to Cambridge, where we spent the day visiting in the low-temperature laboratory of Cambridge University. This laboratory, known as the Royal Society Mond Laboratory, is part of the famous Cavendish Laboratory (Physics). The Mond laboratory was completed in 1933 with Peter Kapitza, now the leading low-temperature physicist of Russia, as its first director.[1] Its present director, Dr. D. Shoenberg, greeted us and explained briefly the facilities of the laboratory and some of the problems under investigation. About 25-30 persons (staff and students) are engaged in research on the properties of matter, principally below 4.2° K (the boiling point of liquid helium). The principal experimental and theoretical studies are concerned with the electrical and magnetic properties of metals, particularly the phenomenon of superconductivity, and with the properties of liquid helium itself.

The laboratory was open for inspection both in the forenoon and afternoon. After tea in the laboratory, we were taken by bus to Oxford, a distance of about 80 miles.

THE OXFORD CONFERENCE

The International Conference on Low-Temperature Physics was held in the Clarendon Laboratory at Oxford on August 22-28, under the auspices of the International Union of Pure and Applied Physics in conjunction with UNESCO. Approximately 200 persons from 13 countries attended. The countries represented were England, Holland, France, Germany, Sweden, Belgium, Switzerland, Spain, Canada, the United States, Australia, Japan and India. A number of prominent Russian scientists had been invited, but the Russian government indicated that it would be impossible for them to attend. The largest foreign delegations came from Holland and the United States, about 35 persons from each of these countries being present.

Three review papers and more than 100 shorter papers were presented at ten sessions. These sessions dealt with the thermal properties of matter, resistivity, properties of liquid helium, superconductivity and the magnetic properties of matter.

The three review papers were given by B. Bleaney (Oxford), F. London (Duke) and H. Fröhlich (Liverpool). Bleaney reported on recent advances in paramagnetism, while London summarized the present state of the two-fluid model of liquid helium. London pointed out several limitations of the macroscopic two-fluid concept and stressed the need for a satisfactory molecular theory of liquid helium. Fröhlich discussed his theory of superconductivity and indicated the direction in which improvements in it could be made.

The subsequent sessions showed clearly that much work remains to be done both theoretically and experimentally before superconductivity and the properties of liquid helium can be said to be thoroughly understood.

A short description of the conference has been given elsewhere.[2] More recently the proceedings of the conference have been described in considerable detail.[3]

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AN ECONOMICAL HIGH-TEMPERATURE INFRA-RED OVEN

By R. B. BELSER* *and* J. W. JOHNSON**

The oven described in this article should prove of interest to persons engaged in experimental work. It can be made from inexpensive equipment available in nearly every laboratory, yet it is capable of heating to temperatures of 700° C. and of reaching them more rapidly than conventional heating units. If a variable voltage source is available, the temperature can be controlled very closely.

In a laboratory, it is often necessary to heat small samples to several hundred degrees Centigrade. Laboratory furnaces are customarily used for this purpose. However, they have the disadvantages of being relatively expensive, slow, cumbersome, and, in some cases, difficult to control precisely. The infra-red oven described in this article has none of these disadvantages.

The sample chamber of the oven can be made from a one-liter beaker (other sizes can be used as desired) lined with a reflecting material. Aluminum foil has been found to be a satisfactory reflector, although evaporated gold plate is more efficient. A 250-watt infra-red reflector is used as the heat source. Temperature adjustment can be made by varying the voltage supplied to the light bulb.

*Research Physicist.
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Infra-Red Light

Infra-red radiation occupies a portion of the electromagnetic spectrum in which the frequencies of the radiation (10^{13} to 10^{14} cycles per second) correspond to the frequencies of vibration of the atoms and atomic groups comprising molecules. Increased vibration of their atomic groups is responsible, of course, for the temperature rise produced in substances exposed to infra-

Figure 1. In this version of the infra-red oven, a gold-plated beaker is used as the furnace, a 250-watt infra-red reflector as the heat source, and a Variac as the energy-input control.

red radiation. Infra-red energy is capable of some penetration of many substances, which accounts for the phenomenon of "internal heating" so useful in infra-red cooking and drying. For example, in infra-red drying of paints and lacquers the rays penetrate through the paint to the substrate, producing a drying action at the interface as well as at the surface. Thus the formation of an outer skin, a source of blistering, is minimized; and the speed of drying is greatly increased regardless of atmospheric conditions. The therapeutic values of infra-red lamps are well known, and their culinary applications are gaining publicity.

An interesting experiment may be performed by placing a raw egg in a small aluminum-foil cup with a 250-watt infra-red lamp a few centimeters above it. Within two or three minutes of the time the lamp is turned on, the egg will be thoroughly cooked. This demonstration provides a lucid example of the penetrating and rapid heating effects of infra-red radiation.

Investigations of the infra-red reflection characteristics of metals have been made by Hagens and Rubens[1], Coblentz[2] and others. It has been shown that a number of metals have high coefficients of reflection in the infra-red region of the spectrum. Among them are gold, silver and aluminum. Gold and aluminum are less subject to corrosion than silver under normal atmospheric conditions, and both may be deposited on glass by vacuum evaporation. Because gold has a higher melting point than aluminum, it was chosen for initial test purposes.

Temperature Measurement

A one-liter beaker has a mouth opening of about 118 mm which fits very nicely over a standard 250-watt infra-red bulb. As shown in Figure 1, the oven consisted of a horizontal beaker with the heat lamp blocking the opening. Temperature measurements were made through a hole in the top of the beaker. The interior of the beaker was coated with gold by vacuum evaporation, and the exterior was covered with a single layer of asbestos paper insulation. A 250-watt infra-red bulb was directed into the mouth of the beaker. The power supply to the bulb was controlled by means of a

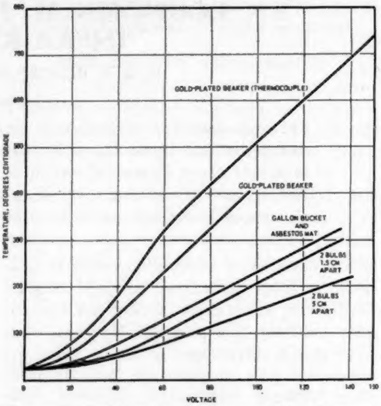

Figure 2. Temperature versus voltage curves for ovens of various materials and for infra-red lamps facing each other at two distances. 0-135 volt Variac.

The temperature of a sample in a field of infra-red light is largely determined by its reflectivity; i.e., highly reflecting objects remain cooler than poor reflecting ones. Thus, the temperature of the air in the oven will generally be much lower than that of objects being heated in it. For example, in tests to determine the heating characteristics of the gold-coated oven both a mercury thermometer (0-400°C) and a thermocouple-type pyrometer (chromel-alumel) were used to measure temperatures produced. Results of these measurements may be seen in Figure 2 which shows the relationship between the temperature and the voltage applied to the lamp. A considerable difference was observed between the temperature indicated by the two different instruments, the thermocouple indicating a temperature about 20 per cent higher than the mercury thermometer. This may be ascribed in part to the greater radiation absorption of the dark thermocouple as compared to that of the much more highly reflecting mercury.

The temperature differences were not so large in an aluminum-coated oven, the percentage difference being only about 10-15

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PHILOSOPHIES CONCERNING ENGINEERING PROBLEMS IN MEDICAL RESEARCH

By FRED DIXON*

Medical research is complicated by the fact that Man's responses to physiological measurements are psychological as well as physical. For example, the sight of a stethoscope often is enough to speed up a patient's heartbeat far beyond its normal rate. The design of new and better instruments for biological research requires the cooperative effort of both medical men and physical scientists; i.e., engineers, physicists, etc. This article discusses some of the factors involved in developing such instruments.

Basic knowledge concerning natural processes, techniques for research, and instruments for making refined measurements often develops in one field yet contributes greatly to advances in ostensibly separate but fundamentally related fields of science. The history of physiology and medicine shows significant contributions at various levels from men whose reputations were made primarily in the physical sciences—notably chemistry and physics; and today, the engineer should be included as well. One reason for the increasing role of the engineer is simply that the thermometer, sphygmomanometer and stethoscope are no longer adequate tools for medical research. The average physician lacks the technical qualifications to design, build, or even operate the electronic and other complicated instruments which he needs. Many universities have established departments of biophysics in order to train personnel for the special requirements of medical research. National engineering societies are beginning to schedule conferences directed exclusively toward the measurements problems of the research clinician. And most hospital and university groups engaged in fundamental studies on health and disease retain at least one engineer or physicist as a project consultant, in addition to the regular working staff of biochemists, physiologists, and physicians. In this connection it may be mentioned that several of the departments in the Emory University Medical School, Atlanta, employ personnel with engineering backgrounds to assist in teaching certain phases of their courses. A recent graduate from the Georgia Tech School of Electrical Engineering, Mr. Robert A. Lee, is now permanently attached as a research associate to the Cardiovascular Research Laboratory at Henry W. Grady Memorial Hospital.

A working knowledge of human anatomy (structure) and human physiology (functioning) is almost prerequisite to attacking even a straight instrumentation problem connected with the study of either normal or pathological man. However, there are several general principles associated with physiological measurements which can be briefly discussed here to show their similarities to, and differences from, the principles encountered in measurements of physical quantities in the more familiar non-living systems. The first step is always to select a quantity for measurement which will, either by itself or in conjunction with other measured quantities, provide usable information about the state or performance of part or all of the system under investigation.

The measuring instrument must be designed with the following considerations in mind: (1) it must possess suitable sensitivity and should, for convenience, have a calibration curve which is independent of environmental conditions or extraneous factors, in the range of accuracy needed; (2) it must be of a size, or have attachments, which will permit connection to the system being measured; and (3) the coupling of the instrument to the system should not affect the quantity to be measured. Conformance with the first two conditions is largely dependent

*Research Physicist.

on the state of the instrument manufacturing art—that is, the problem is one of constructing a physical device of a given theoretical design to certain specifications. Fundamental limitations such as "signal-to-noise ratio" may exist, but these are generally reduced as scientific developments progress. In a sense, the third condition sets the ultimate design requirements on the instrument, and it is here that the greatest difficulties are encountered in physiological work.

Scientists as a whole recognize that it is impossible to perform measurements on a system without in some way disturbing it. The usual solution is to devise a way of sampling the system so that the energy shunted into the sampling device is negligible when compared to the remanent energy represented by the "measured quantity." With some very simple physical systems it is also possible to take into account the energy lost in producing the instrument reading. Thus, to measure the no-load voltage developed by an electrical generator one would connect to the generator terminals a voltmeter having an internal impedance which is large compared to that of the generator itself. For greater accuracy the reading of the meter could be corrected in accordance with the calculated current drain created by the instrument load. One very important point should be noted, however; i.e., that the calculated correction really improves the accuracy of the determination only if the generator develops the same voltage under the slight load of the instrument as it does under no load at all. In the simple electrical example we can correct for this possible source of error too, by determining other intrinsic properties of the generator besides its internal impedance. Since the electrical system consists of only a few distinct and relatively inert component parts, it is not surprising that the performance of power generators can be predicted to a high degree of accuracy and certainty. In the case of biological systems no such simplicity exists.

Insofar as biological systems are concerned, the requirement that the coupling of an instrument to a system should not affect the quantity to be measured is better stated in the following form: the system must be oblivious to the fact that it is being observed. To illustrate, suppose that one wishes to determine the normal strength and rapidity of a man's heartbeat in the "resting" condition, and suppose that he chooses as a satisfactory index of this phenomenon the sound waves generated by the heart at the surface of the chest. For the purposes of the measurement it is clearly valid to neglect the sound distortion introduced by the stethoscope; and the crudeness of the ear as a detecting device can also be overlooked. The acoustic impedance which the heart faces has been changed by the placement of a stethoscope bell on the chest, but this increase in loading appears small when compared to the load which the heart works against in pumping the body's blood. Thus, one may conclude that the degree of mechanical coupling between the instrument and the system is slight. Unfortunately, there are "secondary forms of coupling" also—namely, through the neurohormonal control system—which can radically affect the quantity being measured. The skin of the chest is equipped with numerous local pressure- and temperature-sensitive end-organs. The eyes and ears of the subject receive stimuli originating from the "instrument" (stethoscope plus stethoscopist). Finally, through the involvement of central and sympathetic nervous systems, the whole history of the subject and his unique psychological makeup come into play. Hence, his heart rate may be doubled as a result of the measurement.

One must recognize that the human machine may react at the slightest provocation to prevent or repair possible damage to itself but that it frequently errs in judgment as to what constitutes a hazard against its continued survival and pleasure. Psychological preparation for a test, although not the complete answer, is frequently of considerable value. Many instances exist, however, in which the "feed-back" from the secondary coupling controls is so sensitive and so inextricably bound up with the over-all balance of the body (homeostasis) that only the crudest sorts of approximate measure-

ments can be made. Consolation might, on occasion, be found in the thought that—as with so much other biological information—the normal variations among "similar" individuals would result in that questionable kind of statistical data where the standard deviation of the quantity being measured is of the same order of magnitude as its mean value.

It can not be denied that physiological and medical research problems present many discouraging aspects; there is, moreover, a depressing finality about the thought that "all we have to analyze a brain with is another brain." On the other hand, we are not yet near the point where further efforts would be futile. The fruitful channels for investigation are not always obvious, but that is part of the challenge of biological research—to escape what are for today's science the dead-end streets of Nature, to find by-passes, to map our position in Evolution. To the engineer biological research offers a fertile field for exercise of his skill in improving tools and techniques; such research includes testing new theories and approaches. The game is made doubly interesting by the stakes, since upon the solution of biological problems largely depends each man's ability to survive both individually and collectively with the rest of mankind. Moreover, within the human machine are to be found patterns which determine the shape of all our creations—including the scientific theories and instruments which we develop and use.

* * * *

In a later article, the author will describe the design of a piece of equipment which has recently undergone test at Grady Hospital for the continuous determination of "cardiac output" in human subjects. Its development required solution of a number of engineering problems complicated by extraneous factors peculiar to biological instrumentation work.

RESILIENT FLOORING COMPOSITION

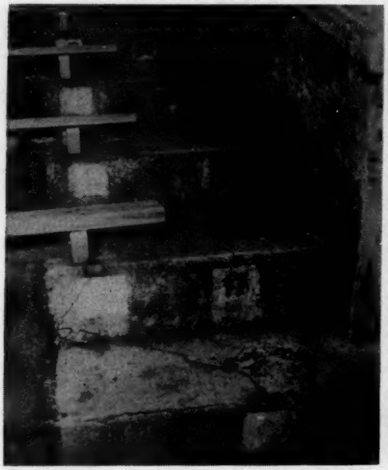
Continued from Page 6

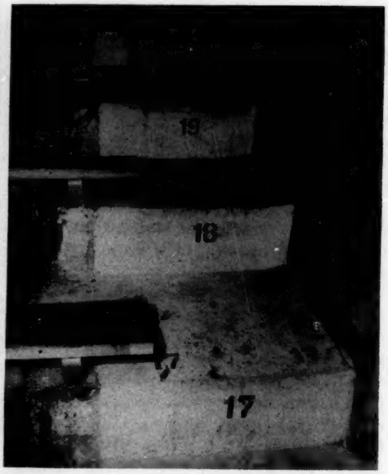
within the specified 24 hours. Systems involving air oxidation (such as oil paints and varnishes) or solvent evaporation (such as lacquers, shellac and cutback asphalt) were quickly ruled out because of the obvious difficulty in obtaining a rapid set in a thick coating. Tests with systems of the intercomponent-reacting type (as typified by hydraulic cements and plaster) and the emulsion type (such as resin emulsions and latices) were not completely satisfying. Further experimentation led to a congenial combination of these two latter types, and the binder problem was solved satisfactorily.

During the early stages of the investigation, laboratory samples cracked, crazed, lost adhesion or exhibited other readily observed shortcomings. Hundreds of samples were prepared and tested before good and consistent results were obtained.

Finally it appeared that the product was ready for field tests. Several applications to exterior steps and walks had been made while work was still going on in the laboratory, more to study possible field techniques than to evaluate performance of a finished, or nearly finished, product. Now application procedures were studied more thoroughly, and slight changes in formulation were made to allow for the wide variability of field conditions. These field tests, some of which will be described more fully later, served to evaluate weathering and resistance to wear and abrasion under practical conditions.

By this time it was apparent that the composition not only met Mr. Freeman's specifications but also possessed properties recommending it for more widespread use than originally contemplated. Coatings 3/16-1/4 of an inch thick offered resilience, long wear and low cost. In fact, any application from a thin film to a massive casting possessed desirable qualities, except that the setting time for very thick coatings was greater than 24 hours. A test floor in an industrial plant demonstrated that the material's resilience enabled it to absorb very





Figures 3 and 4. One aisle of Grant Field Stadium before and after treatment with the composition to reduce wear and deterioration from exposure.

heavy impact loads without chipping or cracking. Repeated hammer blows only indented its surface. Examination of a test application on exterior concrete walks revealed no indication of deterioration from weathering after one and one-half years of exposure. The composition showed inherent resistance to water and repeated scrubbing with cleaning compounds. A separate colorless liquid filler developed to prevent penetration by oils and greases was found to seal the surface very effectively.

As mentioned, it was desired to supply the formulation in two parts, a liquid and a dry mix. This also was accomplished, and when these two parts are combined, either in a mortar box or in a small mechanical mixer, a paste is obtained that is similar to plaster in consistency and working properties. On the job, this paste is applied to the surface, leveled and finish troweled immediately. Normally, the surface will be ready for traffic within 12-24 hours.

ACTUAL INSTALLATIONS

The test applications, although frankly experimental, have proved quite satisfactory. They are described briefly here to indicate a few of the potential uses of the new composition.

The concrete floor at an aisle intersection in an Atlanta woodworking plant had become badly chipped and pitted by the impact and abrasion of steel-wheeled trucks carrying heavy loads. At points the concrete was worn to a depth of one-half inch or more. The new surfacing composition was applied to this area and troweled off to the level of the original floor. The coating was smoothed slightly beyond the edges of the worn area into a thin film. No very careful attempt was made to match the color of the concrete, but after eight months of continuous abuse the patch is hardly discernable except for its smooth and even surface as compared to the worn concrete surrounding it. (See Figure 2.) The paper-thin edge of the patch shows no indication of wear or separation.

One aisle in the east stand of Georgia Tech's Grant Field Stadium was completely resurfaced with the composition. It appears that this application has waterproofed the concrete, provided a long wearing surface and stopped the gradual deterioration from exposure common to concrete structure.

Figures 3 and 4 show the appearance of the aisle before and after application of the composition.

A rectangular steel plate, 12 square feet in area, which serves as a manhole cover on an outside walkway leading to the Research Building, was surfaced with a 1/4-inch coating. After six months of service the coating appears as firmly bonded to the steel as the day it was applied.

A tile porch was coated with a terrazzo-type layer made from a formulation modified for finishing by sanding. The simplicity of application technique and the attractiveness, durability and slight resiliency of the surface produced have elicited favorable comment from several terrazzo specialists.

Satisfactory application over wooden floors to which expanded metal lath had been attached was made in the kitchen pictured on page five. The composition was also applied successfully over old and new plaster walls in the same kitchen and over plaster board in a bathroom. These wall surfaces were given a coat of oil paint within a few days. After six months there is no indication of "alkali burn" or other undesirable effects upon the paint.

Artificial stone of the type previously described was installed around a fireplace and on a hearth, producing an attractive and novel effect as shown in Figure 5. A plywood table top given a similar decorative treatment is withstanding kitchen service admirably.

* * * * *

Many members of Georgia Tech's research staff and faculty contributed valued advice and information to this work. Materials suppliers also cooperated generously by providing both technical information and working samples. However, it is to Mr. O. I. Freeman, the project's sponsor, that particular acknowledgment is due, both for financial support of the work and for the many helpful and practical suggestions that stemmed from his broad engineering and construction background.

PRODUCT RESEARCH FOR SOUTHERN INDUSTRY

Continued from Page 4

of new equipment and which were in keeping with the company's present standards of operation, the fundamentalists launched a program of research for the development of entirely new products and processes which, even under the best of conditions, would require years of investigation and had only about a 60 per cent chance of success. After a few years the company dropped this second project, but it has continued its highly successful applied research, even to the extent of setting up its own research laboratory.

I bring this up not to depreciate the value of fundamental research in any way (because in the long run it is the fundamental research of today which will bring our industrial successes of tomorrow) but, rather, to show that in order to be of most benefit to industry, particularly small industry, research programs must be based upon the needs of the company. Our Southern industries are just learning the benefits of research. They must walk before they can run. If the fundamental research chemists in this case had really studied the company's needs, they would have seen that success with a number of applied research projects and the actual production of new products at a profit would have, in the long run, sold the management on research and would have given them the courage to stick with a long-range research program to a successful conclusion.

Companies, however small, which are based on manufacturing processes requiring reasonable degrees of technical or scientific skills, should spend some of their income on research, that is, on improving their competitive position, developing new products or processes, utilizing their waste materials or, as Kettering puts it, simply "looking for what they will be doing when they no longer can do what they are doing now."

For instance, we have a company in Georgia, for whom the Georgia Tech Engineering

Experiment Station has done some work, which for a number of years has made a successful business of building and selling farm machinery. This is a seasonal business, so that the company has had to take some relatively long-range risks. Through the farsightedness of its management and the research abilities of its technical personnel, it has now developed a new machine which has no seasonal aspects and whose volume of production has greatly outdistanced that of their standard products. Thus, through product research, this company has changed its basic method of operation and its entire outlook on life.

Once it embarks on a research program, a company should maintain it as a continuous part of its operations, in good times as well as in times of trouble. When business is profitable is the time to do research on improving present products and developing new ones. Often, when sales begin to drop competitors who have done research are strategically ahead, and it is either too late for laggard companies to begin research to stay in business or they need many years merely to catch up.

Consider the wood distillation industry which overlooked research and has now about disappeared from the industrial picture. (Incidentally, one or two progressive companies in this field are expanding due to the successes of their research activities.) Or, closer at home, look at the gum naval stores industry and its Government-support crutch as opposed to the wood naval stores industry which is flourishing due to the research of progressive companies such as Hercules Powder and Newport Industries. In Atlanta, we have an outstanding example of progress through research in the Tennessee Corporation which, through the efforts of Dr. J. K. Plummer and others, has succeeded in establishing a chemical industry where many others have failed. This company, by the way, has one of the finest industrial research teams in this area at its College Park Laboratory.

In research, getting the most for your research dollar is what counts. Many companies, who will deny doing research or expending funds for it, are actually spending amounts which, if pegged, would astound the management; and these expenditures are being made without getting useful results. To illustrate, I have a pet example which I would like to cite.

A textile mill desires a new sizing material because, like many others, it is not satisfied with its present mixture. A salesman happens along, claims to have a good sizing material and urges the mill to try it. After much persuasion the mill people agree, proceed to make up a production batch and run a normal day's production of warp yarn through it. The new material behaves a little differently than the starch that they have been using, and it doesn't work well under the conditions employed because of lack of control. The slasher operator is displeased and says so. The batch goes to the looms where, because it hasn't been sized right in the first place, there is more shedding than usual and more stops due to end breaks. Consequently, loom efficiency goes down. Many yards of goods are ruined and sold as seconds. The weave room superintendent is also displeased and says so. The new size is rejected as being no good. The mill has spent considerable time and money, and its managers are convinced that the new product is useless—*but this may be a fallacy*. Actually, the mill people know nothing about the merits of the new size. At no place in their evaluation did they control conditions.

This mill should have done applied research on the size on a smaller scale and should have investigated the merits of many products, not just that of one manufacturing concern. This would have given a more accurate and more complete picture, would have cost less—and the results would have been really useful.

Thus it is seen that in small companies, where funds for research and facilities for manufacture are limited, a careful analysis must be made of any research project which it might undertake. The projects must always be aimed at some practical goal, since the ultimate objective of industrial research is a salable product. In order to accomplish this, constant cooperation must be maintained between research, management, en-

gineering, production and sales. Where a new or improved product cannot satisfy all of these groups, it must be designed so as to be economically produced. It must fit the basic type of equipment and personnel available in the plants so as to be producible. It should be allied to other products made by the company so as to fit into its sales scheme. Finally, it must be capable of being sold at a profit. Carefully planned research by capable technical people and scientists can accomplish these objectives to the great benefit of the company.

"The proof of the pudding is in the eating," so let us consider a few examples in which research has been of direct benefit to smaller units of Southern industry. In May, 1949, Gordon Foods, Inc., came to the Georgia Tech Engineering Experiment Station with a problem which had been costing it many thousands of dollars every summer. Under the prevailing conditions of elevated temperature and high humidity, their potato chips, like those of their competitors, deteriorated rapidly while on store shelves awaiting sale. Taking back bags of chips which had gone stale or rancid involved a most substantial dollars-and-cents loss, and the damage to customer relations when stale chips were inadvertently sold was feared quite serious. I won't burden you with details of the research carried out to obtain a solution to this problem, since the story has already appeared in print elsewhere. However, you may be interested to know that the solution turned out to be quite simple—a small, perforated cellophane packet containing activated carbon and silica gel, which is placed inside the potato chip bag and which very effectively increases shelf storage life even under the most rigorous conditions of temperature and humidity. To protect Gordon Foods, the Georgia Tech inventor has applied for a patent on this packet, and the pending patent will be assigned to the company upon issuance.

Helping companies to improve their products is no new thing with the Station. Quite some time ago we had the opportunity of assisting the S. & H. X-Ray Company, of Atlanta, in developing the first truly portable photo-fluorographic machine for making chest X-rays of the type taken in the tuberculosis detection programs of public health agencies. Machines built to the same design have proved their worth in countless exposures, and the portability of the units has been found of great advantage in making mass surveys of employees in industry, students in schools and colleges, and other such groups.

Our product research is being continued in several current projects, one of which, the development of a new, rugged yet attractive, trowel-applied flooring material is discussed elsewhere in this issue.

Now for the other side of the coin. Regardless of how well research may be done, the knowledge acquired must be translated into plant operations if better products are to be made. Oddly enough, a company will occasionally follow a research project to a successful conclusion and still fail to put the results to use. "Practical" considerations are usually cited in such cases—the required plant investment is too great, operating costs would be increased, etc. In some cases the equally practical advantage of a superior product is overlooked in a kind of shortsighted conservatism that prefers a reasonably comfortable status quo to the prospect of developing consumer acceptance of the superior product that could be produced. For example, let us consider the case of a coated fabrics manufacturer who had been receiving complaints not only on the inferior quality of his own product but also on the shortcomings of all products of the type currently on the market. This clearly indicated demand for a superior product, which was unfilled either by him or by his competitors. He approached a research organization for a solution, and in due time a superior coating was developed which would cost the consumer slightly more to apply than the poorer coatings then available. The manufacturer was pleased with the research, but he decided against production until such time as he would be forced to do so by competition, since, as he reasoned, he was currently enjoying satisfactory sales of the admittedly deficient product. By failing to produce the new coating immediately he not only deprived

the public of the better product it needed and wanted, but he also failed to use the know-how which, by providing desired quality, would have given him a competitive advantage. Greater sales, meaning greater volume of production, could well have been expected to reduce the initially higher production cost to an insignificant amount, if not to wipe it out entirely. The manufacturer also lost the important opportunity of becoming known as a leader in this field. What this could have meant to his advertising copy, alone, is obvious.

Southern industry is on the threshold of a new era. The South has demonstrated that its labor can be trained in production skills to be equal to that available anywhere in the nation. This area has a climatic advantage and is rapidly developing a fighting will to succeed. There is no reason why Southern industries cannot become leaders in their fields. But to do this they must look to research—at first applied research, then fundamental—to provide superior products and techniques that will keep them ahead of competition from all over the world.

Southern scientific talent is as good as any, as the many scientists of Southern birth working in the large research laboratories of the North and East have abundantly proved. Southern industry must have the courage to utilize this talent and to stick with its research programs if it is to gain leadership in the production of manufactured goods and thereby contribute to improved standards of living for the entire world.

INFRA-RED OVEN

Continued from Page 10

per cent. When the two instruments were placed on an asbestos sheet directly under an infra-red lamp, they showed agreement up to 325° C within the limit of error in reading the thermocouple. Similarly, between 25° C and 200° C they were in agreement when immersed in an oil bath. In both of the latter cases the radiation absorption difference was minimized or eliminated by the presence of a relatively uniformly heated medium which acted as an

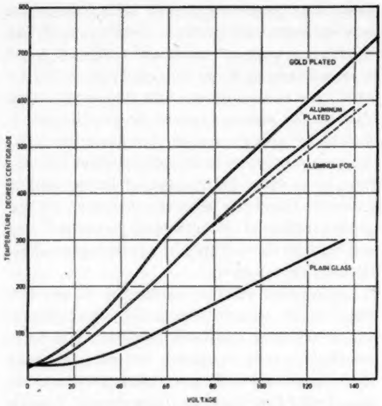


Figure 3. Temperature versus voltage curves for a plain glass beaker, one lined with aluminum foil, one plated with aluminum and one plated with silver.

equalizer or exchange medium. Thus, the instrument was heated primarily by conduction rather than radiation.

In experiments with the gold-plated beaker it was noted that the temperature would exceed the upper limit of the thermometer at a line voltage of 95 volts. The maximum voltage of the Variac (135 volts) was found to give 630° C when the thermocouple was used to measure the temperature.

Because the voltage-temperature graph at 135 volts still showed a considerable slope, a larger Variac was used and the voltage was increased until the bulb failed. The maximum temperature indicated by the pyrometer was 880° C which occurred at 170 volts. The internal components of the bulb collapsed at this temperature and the front end of the bulb protruded, showing that the heat-resistant glass had been softened.

Other Infra-Red Heaters

Since a gold-plated beaker is not readily made or obtained by the average individual, it was decided to run tests with other linings. A plain uncoated beaker, a tinned gallon can, a beaker lined with aluminum foil and a beaker coated internally with evaporated aluminum were tested. Heating

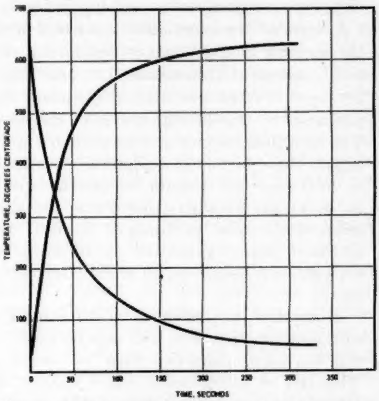


Figure 4. Rates of heating and cooling for the empty oven. These demonstrate that the time lag between experiments can be reduced greatly as compared with that using a conventional convection oven.

curves for these vessels are shown in Figures 2 and 3. The aluminum foil, remarkably enough, gave excellent results.

Experiments with single lamps directed onto an asbestos pad and two lamps facing each other were run for purposes of comparison. A single lamp shining downward on a small piece of asbestos from a distance of a few centimeters produced temperatures in the range 250°-300° C and yielded a temperature-voltage curve indistinguishable from that obtained with the tinned gallon can. For two lamps face to face, similar temperatures may be expected, as shown in Figure 2. In each of these setups convection currents and scattering of the radiation might be expected to prevent high-temperature heating.

For the plain glass beaker and the gallon can, temperatures approximately the same as those observed with the lamp directed onto asbestos were noted, even though convection cooling had been largely eliminated by placing the thermocouple inside each of the vessels. Upon coating or lining the interior of the beaker with gold, aluminum or aluminum foil, the temperatures observed were approximately doubled. At 135 volts they varied from 535° C to 630° C. This increase was undoubtedly due to the light trapped by the reflecting surfaces and the consequently greater interception of radiation by the object being heated.

Figure 4 shows the rate of heating or cooling of the empty oven. It can be seen that there need be no delay in experiments due to warming the oven. In addition, it is possible to change the operating temperature without a lengthy wait for the thermal equilibration of a large mass of insulation. These related advantages are not present in even the best convection ovens.

The oven has been found useful in accelerating the diffusion of thin metal films into metal substrates, and it would appear that it might have limited metal-tempering applications.

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LOW-TEMPERATURE RESEARCH

Continued from Page 8

There was much opportunity for members of the conference to engage in informal discussion. This was made easy by having coffee and tea in the laboratory each day to provide a break in the morning and afternoon sessions. Also, those attending the conference were housed in two of the colleges. I was assigned to Brasenose College, chartered in 1512. This being vacation time, few students were in evidence. All of us in Brasenose ate together in the College dining hall seated on wooden benches at long wooden tables.

On Sunday morning, August 26, a tour of the low-temperature laboratory was arranged. Dr. F. E. Simon is director of this laboratory in which about 60 persons (staff and students) are engaged in research on low-temperature problems. The principal interests of the laboratory are in liquid helium, superconductivity, magnetism, re-

sistivity and thermal properties of matter, e.g., specific heats and thermal conductivity.

It was a pleasant surprise to meet a former Georgia Tech student, Mr. Hugh Long, a graduate student and Rhodes scholar working with Dr. Simon. I learned from him that Mr. Al Newton, a recent Georgia Tech graduate and now a Rhodes scholar, was expected to begin work at Oxford in September.

On Sunday afternoon alternate motor tours were arranged to Stratford-on-Avon, Shakespeare's birthplace, and Blenheim Palace, ancestral home of Winston Churchill. I spent several enjoyable hours in Stratford visiting Shakespeare's birthplace and walking along the banks of the beautiful Avon river.

On Monday evening the conference dinner was held in Brasenose College. This was a delightful occasion, notable in my mind for its careful planning, the toasts, the good fellowship and the number of excellent wines and liqueurs served.

On Tuesday, August 28, the conference closed and good-byes were said to old and new friends. Many of those present left for London to attend the 8th International Congress of Refrigeration.

Refrigeration Congress

The International Institute of Refrigeration was established in 1920 by a Convention signed by forty governments. This Institute sponsors from time to time an International Refrigeration Congress at which technical, economic and political developments affecting the field of refrigeration are discussed. The 8th such Congress was held in London August 29-September 5.

The work of the Institute and the Congresses is carried on by seven commissions. Briefly, these commissions are concerned with the following problems: Commission I—scientific problems of low-temperature physics and thermodynamics; Commission II—physical-technical problems of industrial refrigeration; Commission III—fundamental biochemical and biophysical studies; Commission IV—refrigeration machinery and plants; Commission V—application of refrigeration to storage and processing of foodstuffs: Commission VI—refrigerated transport; Commission VII—research education, economics, statistics and legislation.

I attended the ceremonies connected with the opening of the Congress and one of the four sessions of Commission I. I also made a tour of the research and development department of the British Oxygen Company. The technical sessions of Commission I were largely devoted to the design and operation of hydrogen and helium liquefiers, liquid-air and other gas-separation plants and low-temperature heat exchangers. Selected abstracts of papers presented at the Congress are currently appearing in *World Refrigeration*.

It appears that both ice and mechanical refrigeration is much less widely used in the European countries than in America. This lack of refrigeration has a marked effect on the shopping habits of the average housewife who must use perishable foods as soon as they are purchased.

Visits to Other European Laboratories

During the period September 1-20 I visited a number of low-temperature laboratories in France, Germany, Holland and Belgium. I was fortunate in having already met the directors of several of these laboratories at the Oxford conference. My intention was to see at first hand the facilities of the laboratories and to talk with the staff about problems of mutual interest in the low-temperature field.

I flew to Paris on Saturday afternoon, September 1, and on September 3 visited the laboratories of the Centre National de la Recherche Scientifique (C.N.R.S.) which are located in Bellevue, a suburb of Paris. This is a large establishment with many different types of laboratories. One of the largest is the Cotton laboratory, under the direction of Dr. P. Jacquinot, where research on magnetic properties is carried on with the aid of the very large Cotton electromagnet. This magnet is capable of producing fields up to 60,000 gauss. The low-temperature facilities, consisting of small hydrogen and helium liquefiers, are located in the Cotton laboratory. These facilities are used to study the magnetic properties of matter down to helium temperatures. Studies of the absorption spectra of crystals at liquid-helium

temperatures are in a preliminary stage.

I also visited the rare earth laboratory of Dr. F. Trombe, with whose work on the preparation of rare-earth metals I was already well acquainted. I found work proceeding on the separation of rare earths by ion exchange and on the preparation of very pure specimens of the rare-earth metals.

On September 4 I left Paris by train for Stuttgart, Germany, arriving there in the evening. Here I spent several days visiting with relatives. On one day I visited several of the institutes of the Technische Hochschule. Many of the buildings of the Hochschule were severely damaged by bombing in the last war, but they have now been rebuilt or repaired in part. There appeared to be considerable need for laboratory equipment. Apparently no low-temperature work is in progress there. On the last day of my stay in Stuttgart I was pleasantly surprised to meet Hans Wagner, a student at the Technische Hochschule, who had spent the year 1950-51 as an exchange student in chemistry at Georgia Tech. He had left Atlanta a few days before me for New York on his way back to Stuttgart.

On Saturday morning, September 8, I left by train for Zurich, Switzerland, and the following day went on to Innsbruck, Austria. The trip from Zurich to Innsbruck was especially beautiful, with the Swiss Alps towering high above the train as it climbed steadily upward to the Arlberg tunnel.

After an evening and morning of sightseeing in Innsbruck, which included a climb by cable car to the mountain top of Hafelekar, I left for Munich arriving there on the evening of September 10.

September 11 I spent in visiting the low-temperature laboratory of the Technische Hochschule of Munich. I met Professor Meissner (director of the laboratory) and his son at Pasing (a suburb of Munich) and drove with them to Herrsching, a village about 30 kilometers from Munich, where the low-temperature laboratory is located. Much of the apparatus was in storage at this location during the war, and after the war it was decided to set up the laboratory there because of the shortage of space at the Technische Hochschule in Munich. A small liquid-air plant and a helium expansion-engine liquefier, capable of producing about 3 liters of liquid helium per hour, are in operation. Present investigations of Dr. Meissner and his two research assistants are concerned with the electric and magnetic properties of superconducting metals in the intermediate state, the resistivity of metals

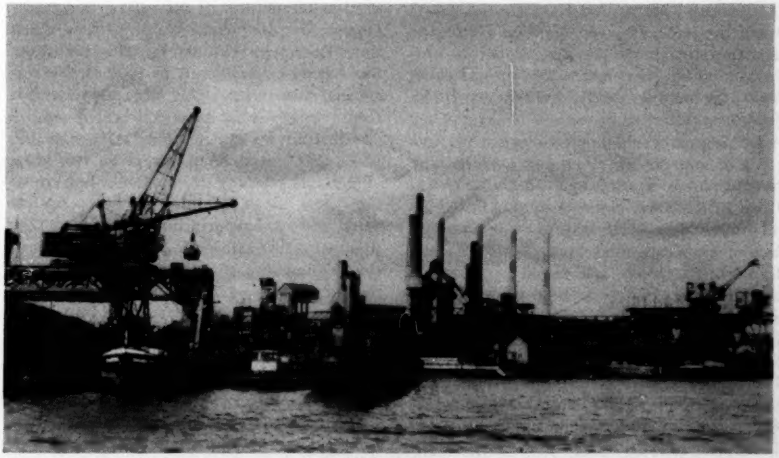

Figure 3. Rotterdam's harbor and dockside industrial area were Dr. Ziegler's first view of the Netherlands.

below 1° K (it is hoped to reach these low temperatures by rapid pumping) and the effect of impurities on the residual resistivity of metals.

On September 12 I left Munich very early in the morning for Erlangen, a town located about 20 miles north of Nurnberg. Here I spent the day visiting the Physical Institute of the University of Erlangen. Dr. Rudolf Hilsch, director of the Institute, and his research associates very kindly showed me the facilities of the laboratory and explained the problems being investigated. Facilities are available for the production of modest amounts of liquid air, liquid hydrogen and liquid helium. Liquid helium is produced in a number of small capacity (about 40 cc) liquefiers of the Simon expansion type. One of the problems receiving much attention is the resistivity of metal films (primarily metals known to be superconductors) deposited at various temperatures, particularly at liquid-helium temperatures. The effect of aging and heat treatment on the electrical behavior of the films is also being studied.

From Nurnberg I went to Frankfurt and thence to Bingen on the Rhine. Here I boarded a river boat which took me down the fabulous Rhine, past the ancient hilltop castles and vineyards, to Cologne where I spent the weekend with relatives. There was a rather heavy river traffic of barges and freight boats, the Rhine being navigable from its mouth at Rotterdam to Basle, Switzerland.

On September 17 I left Cologne for Rotterdam, and on the next day I visited the world-famous Kamerlingh Onnes Physical Institute of the University of Leiden. This laboratory has been continuously engaged in low-temperature research since 1882 when Kamerlingh Onnes first began his work at the University. There are two professorships of physics at Leiden. One is held by Dr. C. J. Gorter who is also director of the laboratory, and the other by Dr. A. van Itterbeck who divides his time between the Universities of Leiden and Louvain (Belgium). The laboratory personnel consists of 50-60 members of the scientific staff (including graduate students) and about 20 technicians. In addition, there is a large Technicians School with 100 students and about 20 instructors. The laboratory facilities are very good, liquid air, hydrogen and helium being available in considerable quantities. Recently the Institute received a grant of one million Dutch guilders (about $250,000) for the construction of new cryogenic facilities. With these funds a new large-capacity air plant, and new hydrogen (15 liters/hour) and helium (6 liters/hour) liquefiers are being installed.

The research program at Leiden is a very broad one. It includes extensive studies of the resistance of metals and alloys, of liquid helium and of nuclear resonance. Extensive studies are being made of the magnetic properties of matter, and the measurement of thermodynamic temperatures near absolute zero (0° K). It is interesting to note that the lowest temperature which has been reached in these studies is 0.0014° K[8]—the closest approach to absolute zero reported by any laboratory to date.

The Technicians School is unique, and therefore will be described in some detail. Its purpose is to train technicians for the trades of instrument making, glass blowing and the construction of optical instruments. The need for trained technicians to work in the low-temperature laboratory was seen by Onnes, and he began training men along these lines prior to 1900. In 1901 the School was officially established as part of the recognized function of the laboratory, and it continues so to the present day.

The students are usually 17-19 years old when they enter. They are given two years of general training in machine-shop practice, glass blowing and elementary optical work, such as lens grinding. They then take their student examination which consists of the making of a simple instrument. During the next three years the men specialize in (1) glass blowing, (2) mechanical and metal working or (3) the construction of optical instruments, at the end of which time they must make a quite difficult instrument for their apprentice examination.

During these five years the student is strongly urged (I believe it is mandatory for the first two or three years) to attend

the evening school of the University four nights a week to take basic courses in chemistry, physics, mathematics and such other courses as will be of use to him in his special field. At the end of five years he receives a diploma.

In general, the students work part time in the cryogenic laboratory during their stay in the Technicians School. They construct, as part of their course work in this School, various pieces of equipment needed by the laboratory and suited to their particular stage of training.

Upon completing their work, the students become technicians and instrument makers for other physics laboratories and industrial research organizations both in Holland and aboard. Quite understandably, they are much in demand. The best men are often added to the technical staff of the laboratory and the Technicians School.

After a number of years of practice a man may take an examination for a master's rating. The problem set here is generally a very difficult one, and not many such ratings are given.

On September 19 I left Rotterdam for Brussels, and in the afternoon I visited the Institute for Low-Temperature and Technical Physics at the University of Louvain, Belgium. This is the largest university in Belgium, having 8000 students. The low-temperature facilities here consist of a liquid-air plant (9.5 liters/hour), a small hydrogen liquefier (3 liters/hour) and a Collins helium cryostat. The Collins cryostat, installed in April-May 1951, is, I believe, the only such unit in a continental university laboratory.

Among the research problems being investigated are the structure and electrical properties of sputtered and evaporated metal films. The films, usually prepared at room temperature, are cooled to the temperatures of liquid hydrogen and helium, and their resistances are then measured. Both superconducting and nonsuperconducting metals are being investigated. Also under study are the absorption and velocity of sound in gases at low temperatures, ultrasonic absorption in liquids and magnetic-relaxation phenomena. A new magnet, capable of producing 60,000 gauss, is being installed to extend the magnetic studies to lower temperatures.

The Trip Home

On September 20 I flew back to London. The return trip to America was again made by the facilities of the Fleet Logistic Air Wing. I boarded the plane in London on September 24 at 4:00 p.m., and I arrived at Patuxent River, Maryland, at about 6:00 p.m. on September 25. As I boarded the plane in London, I found that one of my fellow passengers was Lt. (j.g.) Henry DeCourt, formerly of the Engineering Experiment Station at Tech, who was returning to the United States after spending eight months in the Mediterranean area.

General Impressions

A first trip to Europe must always be a fascinating experience. In my own case, the opportunity to attend two international scientific conferences, to meet men and to visit laboratories whose names are famous in science, to visit relatives known only through letters and to see historic sights all combined to make the trip a memorable one indeed.

I was tremendously impressed with the extensive research programs and the ability of the low-temperature groups at Oxford, Cambridge and Leiden.

I was impressed with the international character of science. Outstanding theoretical and experimental ability were clearly not the possession of any single national group, nor was there any tendency to assume that these abilities were so distributed.

I was impressed with the courtesy and friendliness of the Europeans to strangers. Many times people went far out of their way to help me even before I had occasion to ask for assistance.

I was impressed with the extensive war damage, particularly in Germany, and with the will to rebuild.

Finally, I was impressed with the importance of traditions which arise from hundreds of years of living in a country—the ancient Roman walls and roads of England and Germany, the Rhine with its thirteenth century castles, Cologne and its towering

two-spired cathedral, Westminster Abbey with its historic dead, the ancient colleges of Oxford and Cambridge.

I felt the newness of America when I returned—its almost primitive drive, its vastness, its history which is so closely related to that of England.

It was good to be home again!

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BUILDING FOR THE FUTURE

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that this list reads like a *Who's Who* of industrial organizations. Du Pont, prior to World War I a relatively small manufacturer of black gunpowder and now titan of the chemical world, stands fifth on the current list and, in similar tabulations, was fourth for the period 1941-43 and fifth for 1946-48. Union Carbide & Carbon, born of research conducted at Mellon Institute during the 1920's, is high up among the leaders (in twenty-first place) and has been there for some time (ninth in 1941-43 and sixteenth in 1946-48).

Illustrative of the truism that research is necessary to maintain competitive advantage are the standings of major electrical manufacturers. General Electric has headed the list of all companies in each of the three surveys. In the present one, RCA and Westinghouse are tied for third place. RCA was fifth in 1941-43 and second in 1946-48, as compared with Westinghouse's third in the first survey and fourth in the second. In the highly competitive petroleum industry, Standard Oil Company of New Jersey leads the pack in fourth position, with Phillips Petroleum, Shell Oil and Socony-Vacuum all receiving more than 100 patents per year in the latest period to take eleventh, twelfth and thirteenth places, respectively.

We should point out that the patent assignment practices of various companies vary too much to permit a direct comparison of their research activities on the basis of patents issued in their name. For example, a complex corporation may prefer to have all patents originating in its affiliates issue under the parent company's name, while another may not. However, this much seems clear from study of the list—recognized leaders in competitive industries of various kinds have not been content to rest on their hard won laurels. Instead, they have continuously sought to develop new products and processes through research and then to secure them for themselves through patents.

Smaller companies may not have the funds available to carry on a large number of research projects simultaneously or to maintain the necessary laboratories and personnel. However, they need not pass up the benefits of research for these reasons. Non-profit engineering experiment stations and research institutes offer these smaller companies an excellent opportunity to explore new ideas in as much confidence as desired and to secure patents on the resulting fruits of research as readily as any larger company with its own laboratory and employees. The company sponsoring such research can limit its expenditures to precisely the subjects of its interest without purchasing equipment vitally essential to its present studies but nonapplicable to future work. Moreover, through sponsored research the small company can hire the services of highly competent scientists and technologists on the basis of the time they actually spend on the specific job. This would seem preferable to grappling with the problem of obtaining such men in the first place and supporting them afterward through those times when company activities and income may not justify work utilizing their full talents.

Thus it appears that any company, regardless of size, which approaches the new year with a desire to do even better than in the past, might well consider research as a means to its end. The demonstrated success of those companies high on the patent list may not be a guarantee, but it certainly is an attractive promise.